The Risk Sharing Role of Foreign Aid in Developing Countries

Faruk Balli[*], Peng Fu[†] and Eleonora Pierucci[‡]

Abstract

The effects of foreign aid on economic growth have been extensively investigated over the past 40 years. However, even though foreign aid can be a significant source of insurance against domestic output shocks for developing countries; its risk sharing role has not been well explored. Using a sample of 22 developing countries over the period 2003–2013, we estimate the degree of income smoothing generated by foreign aid serving as a channel of international risk sharing. Our results indicate a strong evidence of income smoothing via foreign aid. In particular, for the period 2003–2008, they offset about 4-6% of the output shocks. Furthermore, we investigate the determinants of the extent of risk sharing via foreign aid, recognizing the diversification of the originating countries as a key factor. Surprisingly, humanitarian aid seems to have a negative effect, which might be explained by its predominant role in the short run.

Keywords: Foreign aid; Income smoothing; Risk sharing; GMM-system

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[*] Massey University, School of Economics and Finance.

[†] Massey University, School of Economics and Finance.

[‡] University of Basilicata.

1. Introduction

This work aims to merge the risk sharing literature with the foreign aid and economic growth literature. If the economic literature has already recognized the positive effect of foreign aid on growth in developing countries (e.g. see Arndt *et al*., 2010), very little is known about its role in terms of income smoothing (risk sharing). We fill this gap in the literature by investigating to what extent foreign aid is a source of insurance against domestic output shocks for developing countries.

This issue is even more relevant nowadays, given the rapid growth of economic integration which favours countries' interactions and widens income and consumption insurance opportunities against domestic output shocks. According to the theoretical framework,[§] unlike financial autarky, countries in an open economy can invest in foreign assets and trade with each other. Therefore, by pooling risk together with another country, a country's income and consumption should solely depend on systemic risk, thus domestic consumption should be independent of domestic output. This notion is known as "full risk sharing".

Many studies have tested the hypothesis of perfect risk sharing at the macroeconomic level; however, the extant literature has been able to detect only partial risk sharing (Obstfeld, 1986, 1994; Backus and Smith, 1993; Tesar, 1995; Canova and Ravn, 1996 and Lewis, 1996, among many others). Even without the existence of full risk sharing, gains from risk sharing still can be substantial. Sala-i-Martin and Sachs (1991) opened up a new strand of literature estimating that the level of risk sharing through federal government's taxes and transfers in the United States (US) was about 60%. Later, Asdrubali *et al.* (1996) shifted the focus from testing for full risk sharing to measuring the level of risk sharing through different channels. Since then, the economic literature has extensively investigated risk sharing channels, the extent to which risk is diversified through these channels, the patterns of risk sharing channels in different regions of the world, and how the importance of each channel varies depending on the group of countries among whom risk is pooled.

[§] See Obstefeld and Rogoff (1996).

Among the most relevant channels of international income smoothing, the literature has recognized the factor income and the saving channels (Asdrubali *et al*., 1996; Sørensen and Yosha, 1998; Balli *et al*., 2011, 2012a). Considering factors within the factor income channel, Balli *et al*. (2011, 2014) highlight the role of income from net financial asset holdings as well as from interest receipts and equity dividend payments. Balli *et al*. (2013) also found that there is a significant portion of shocks smoothed through another component of the net factor income: foreign remittances (in particular with reference to the economically less-developed Middle Eastern and North African countries). Along the same lines, Balli and Rana (2015), who investigated the degree of risk sharing via remittances among 86 developing countries, found that, on average, 5% of shocks were smoothed during 1990–2010 through this component of the factor income.

Similar to remittance flows, foreign aid is an important external financing source and foreign exchange earning source for many developing countries. Arndt *et al*. (2010) stated that the contributions of foreign aid in developing countries have "over the past 40 years stimulated growth, promoted structural change, improved social indicators, and reduced poverty." (page 6). As the importance of foreign aid has been recognized over time, the amount of foreign aid channelled to developing countries has increased greatly. From 1994 to 2013, the total foreign aid received by all developing countries rose from US$60,174.56 million to US$150,432.02 million of US dollar (see Figure 1).

The significant increase in the amount of foreign aid received by developing countries and the recognition of the potential role of foreign aid in smoothing domestic shocks (e.g. Balli and Balli, 2011; Yehoue 2011) call for a systematic analysis of the risk sharing role of foreign aid on a large sample of developing countries, filling a relevant gap in the international finance literature. Indeed, as the third largest component of international transfers, foreign aid is an important channel where the mechanism of risk sharing can take place.

Using a sample of 22 developing countries over the time horizon 2003–2013, we show that a fraction of idiosyncratic output shocks is indeed smoothed through foreign aid.

Furthermore, we investigate the determinants of the foreign aid channel of smoothing and identify two main issues that determine the extent of risk sharing via foreign aid. The first one is the impact of the different disbursements of Official Development Assistance (ODA); the second is the degree of diversification of the source of the foreign aid: the more diversified the source of the foreign aid is, the greater the extent of the risk shared through foreign aid.

The rest of this paper is organized as follows. In Section 2, we briefly recall the literature. Section 3 provides the theoretical framework and the empirical model of foreign aid as a channel of risk sharing. In Section 4, we present the data and the results are reported in Section 5. Section 6 concludes the paper.

2. Literature

There is a large strand of literature that has explored the existence of perfect international risk sharing: if full risk sharing is achieved, a country's consumption will no longer respond to idiosyncratic shocks. Notwithstanding that this hypothesis has been largely rejected by the empirical evidence, as outlined above, the gains from risk sharing still can be substantial (*inter alia* Sala-i-Martin and Sachs, 1991 Van Wincoop, 1994; Asdrubali *et al.*, 1996; Arreaza *et al*., 1998; Sørensen and Yosha 1998; Kim and Sheen, 2007; Balli *et al.* 2012b). In this framework, Asdrubali *et al.* (1996) first focused on measuring the risk sharing achieved through different channels of smoothing. Their study showed that in the US, about 39% of output shocks were smoothed by capital markets, 13% by the federal government and 23% by credit markets. Sørensen and Yosha (1998), applying the methodology of Asdrubali *et al.* (1996) to international data, accounted for two more channels of risk sharing: international transfers and capital depreciation.

On this foundation, a wide body of literature has grown, which explores the extent and the determinants of the different channels of smoothing among different groups

of countries.[**] One of the channels on which the literature has focused its attention is the net factor income channel, since it represents the financial markets and the international transfer channel of smoothing. Therefore, the net factor income channel should be the most sensitive to the increased financial/economic integration experienced since the beginning of the globalization era. These studies include Balli *et al.* (2011), who decomposed the net factor income flows into factor income inflows and factor income outflows; Balli *et al.* (2012a), who also examined the channel of capital gains, and Balli *et al*. (2014) who highlighted the role of interest receipts and equity dividend payments.

As an important component of international transfers, the channel of remittances has also been examined by the previous studies. Balli and Balli (2011) found that 19% of shocks were smoothed during the 2001–2007 period in Pacific Island countries. Balli *et al.* (2013) also found that there is a significant portion of shocks smoothed via the channel of remittances in the less economically developed Middle Eastern and North African countries. Further, Balli and Rana (2015) detected that for developing countries, remittances accounted for about 5% of income smoothing over a wide time horizon ranging from 1990 to 2010.

As for foreign remittances, in developing countries, foreign aid is a potential source of growth as well as income stabilization (income smoothing). However, although there is a significant amount of literature that has studied the effectiveness of foreign aid, there is a lack of studies that evaluate its role as a potential buffer against output shocks.

Most of the studies have focused on the relationship between aid and growth in developing countries. In the early literature, studies inspired by the Harrod–Domar model and the two-gap Chenery–Strout model assumed that if aid is all invested, it is simple to calculate the amount of aid needed to achieve a certain growth rate, based

[**] See among others, Sørensen and Yosha (1998), Balli and Sørensen (2006) and Demyanyk and Volosovych (2008) for European and Organization for Economic Co-operation and Development (OECD) countries; Kim *et al*. (2006) for Asia; Yehoue (2011) for African economic and monetary unions; Balli and Balli (2011) for Pacific Island countries; Balli *et al.* (2013) and Balli and Balli (2013) for Middle East and North African countries; and Rana and Balli (2015) for New Zealand and Australia.

on the stable linear relationship between investment and growth. The positive impact of foreign aid would be achieved through filling either a foreign exchange or a savings gap (see Rahaman, 1968; Griffin and Enos, 1970; Weiskopf, 1972; Papanek, 1972; Hansen and Tarp, 2000). In these studies, foreign aid was not separated from other foreign capital inflows.

Shifting away from the aid–savings relationship, a different strand of literature focused on the relationships among aid, investment and growth. In these studies, a positive link between aid and investment has been found (Papanek, 1972; Hansen and Tarp, 2000). However, cross-country evidence has failed to establish a clear positive link between aid and growth. In other words, foreign aid does not seem to promote growth (Mosley, 1987; Mosley *et al.*, 1987; Michalopoulos and Sukhatme, 1989). At the microeconomic level, there is a clear link between aid and growth; however, the macroeconomic impact of aid on growth is still unclear. Mosley (1987) named this the "micro–macro paradox". Hansen and Tarp (2000), reviewing these studies, found that most studies used total foreign capital inflows instead of foreign aid. The results from the reduced form in their study suggest a positive link within the aid–savings–investment–growth chain. More recent studies have also reported the positive macroeconomic impact of aid on growth (Mishra and Newhouse, 2009; Riddell, 2007; Temple, 2010; Arndt *et al*., 2010)

Recently, a number of studies began to test new growth theories in order to analyse the impact of aid on growth. A positive impact of foreign aid on growth was found by Hadjimichael *et al*. (1995), Durbarry *et al*. (1998) and Burnside and Dollar (1997). However, Hansen and Tarp (2000) questioned their approach of not including the non-linear effects of aid on growth; in addition, Easterly (2003), using the same approach as Burnside and Dollar (1997) but with an expanded dataset, found no support for the conclusion that aid works in a good policy environment.

Most recently, the positive impact of foreign aid on growth has been widely proved in different aspects: the long-run positive effect of foreign aid on growth, the time series evidence and the meta-analysis evidence (Arndt *et al.* 2010; Juselius *et al.*,2013; Mekasha and Tarp, 2013).

Apart from exploring the effects of foreign aid on savings, investment and economic growth, many studies have tried to find different aspects of foreign aid such as economy stabilization. Casella and Eichengreen (1994) found that foreign aid can accelerate stabilization if the aid is announced and disbursed relatively early in the inflation process. Collier and Dehn (2001) found that broadly contemporaneously increased aid could mitigate the adverse effects of negative export price shocks. Guillaumont and Le Goff (2010) showed that aid flows can stabilize export and growth volatility. Savun and Tirone (2012) found the role of foreign aid in preventing civil wars by smoothing negative economic shocks. Combes *et al.* (2012) revealed that the volatility and the level of household consumption were significantly affected by food price shocks, and that foreign aid can smooth household consumption by dampening food price shocks.

Therefore, recent studies have revealed the stabilising role of foreign aid. The international risk sharing literature also indicates the possibility of foreign aid as a channel of income and consumption smoothing (Balli and Balli, 2011; Yehoue 2011). For instance, Yehoue (2011) found that foreign aid played an important role in international risk sharing. According to his study, between 1980 and 2005, about 66% of shocks were smoothed via foreign aid from France in African Economic and Monetary Community and 50% in West African Economic Monetary Union. However, a systematic analysis over a large group of developing countries and for a significant time horizon is still missing in the literature. This work aims to fill this gap.

3. The Empirical Model

3.1. Risk sharing via foreign aid

When a developing country faces a recession, the amount of ODA this country receives may increase for the purposes of promoting economic development, reducing poverty or improving social indicators. The increased amount of foreign aid will be able to provide insurance against domestic output shocks.

Even without receiving increased foreign aid, the amount of foreign aid that developing countries receive will be a larger fraction of output when countries are in

recession. Over the 2003–2013 period, the foreign aid that our sample countries received constituted a large part of output, especially for the period 2003–2008 (Figure 3). The annual average foreign aid distribution to gross domestic product (GDP) ratio between 2003 and 2013 across the sample countries varies from –0.12% (Thailand)[††] to 13.68% (Slovenia) (Figure 2). For the time horizon 2003–2008, the annual average ODA to GDP ratio is even larger: Macedonia (5.14%), Bosnia (6.80%), Cameroon (7.06%), Slovenia (27.19%) (Figure 3).[‡‡]

We follow the regression model of Balli and Balli (2011) and Balli *et al.* (2013) to quantify the degree of risk sharing via foreign aid.[§§] The regression models examine whether domestic income plus foreign aid flows fluctuates less than one-to-one with output changes. Put simply, we introduce a new identity, GDP_{flow}, which represents the sum of GDP and foreign aid flows (ODA). Using this identity to measure income risk sharing via foreign aid, we run the following regression:

$$\widetilde{GDP_{flow_{it}}} = v_t + \beta \widetilde{GDP_{it}} + \varepsilon_{it}, \quad (1)$$

where $\widetilde{GDP_{it}}$ represents the idiosyncratic part of output calculated as the real GDP per capita growth rate of country *i* in period *t* minus the world real per capita GDP growth. $GDP_{flow_{it}}$ has a similar interpretation to $\widetilde{GDP_{it}}$, v_t represents the time-fixed effects that account for cross-country common effects.

For estimating the Equation (1), the coefficient β measures the average degree of the co-movement of $\widetilde{GDP_{flow_{it}}}$ with $\widetilde{GDP_{it}}$. The corresponding series $1-\beta$ directly quantifies the fraction of idiosyncratic risk to country *i*'s **GDP** insured through foreign aid (i.e. risk sharing). Full risk sharing implies that idiosyncratic shocks to **GDP** and GDP_{flow} are uncorrelated, thereby generating a coefficient β equal to zero

[††] The net ODA disbursements for Thailand were negative in 2003, and between 2005 and 2013 according to the OECD database.

[‡‡] We excluded extreme examples where a country was heavily reliant on foreign aid over the sample period, like Afghanistan.

[§§] Their empirical specification is based on Asdrubali *et al*. (1996) and Sørensen and Yosha (1998).

in the regression; accordingly, $1-\beta$ approaches to 1. Similarly, if GDP and gdp_{flow} are perfectly correlated, we would expect $1-\beta$ to approach 0, thus indicating non-smoothing of output shocks. In the case when idiosyncratic GDP_{flow} reacts more than one-to-one to idiosyncratic GDP, $1-\beta$ may turn out to be negative, pointing towards dis-smoothing of shocks.

In order to obtain the *t*-statistics for the equation, we convert Equation (1) as follows

$$\widetilde{GDP_{it}} - \widetilde{GDP}_{flow_{it}} = \alpha_t + \beta\widetilde{GDP_{it}} + \varepsilon_{it}. \qquad (1.a)$$

Equation (1.a) empirically presents the extent of risk sharing via foreign aid flows and produces the *t*-statistics for the estimations. In order to simplify the reading of the results, the estimations of risk sharing via foreign aid presented in the tables are based on Equation (1.a)

3.2. The determinants of risk sharing via foreign aid

Along with an evaluation of the potential smoothing role of foreign aid, we investigate the determinants of risk sharing through foreign aid. We analyse two main determinants.

The first determinant is the ratio of disbursement of ODA to GDP among different sectors. We believe that the ODA disbursement could influence the strength of the smoothing. We examined the five main sectors: the production sector, the health and population sector, the education sector, the humanitarian aid sector, and the economic infrastructure and services sector.

The second determinant is the degree of diversification of the sources of the ODA. If the sources of foreign aid are more diversified, the probability of countercyclical foreign aid sources might increase. Accordingly, we collected the top three donors' combined foreign aid to ODA ratio to measure the degree of diversification of the sources of the ODA.

Our empirical strategy is mainly based on the contributions of Asdrubali *et al*. (1996), Sørensen and Yosha (1998), Melitz and Zumer (1999), and Sørensen *et al*.

(2007), and more precisely, follows a recent work by Balli and Rana (2015) by estimating the panel equation below:

where v_t captures the time-fixed effects, $\widetilde{GDP}_{it}$ represents the idiosyncratic component of output calculated as the log difference of GDP per capita. Similarly, $\widetilde{GDP_{flows}}_{it}$ represents the idiosyncratic part of output including foreign aid (ODA). The coefficient β_0 represents the average risk sharing via foreign aid for the sample period 2003–2013, we also split our sample period into 2003–2008 and 2009–2013. Trend changes in risk sharing that may not be directly caused by foreign aid are captured by the trend variable $t - \bar{t}$. *PS*, *HP*, *E*, *HA* and *EIS* represent the five sectors (respectively, the production sector, the health and population sector, the education sector, the humanitarian aid sectors, and the economic infrastructure and services sector) for the ODA disbursement to GDP ratio. TOP3 represents the top three donors' combined foreign aid to ODA ratio. All these variables are included demeaned by their cross-country average ($\overline{PS}_t$, $\overline{HP}_t$, $\overline{E}_t$, $\overline{HA}_t$, $\overline{EIS}_t$, $\overline{TOP3}_t$).

Both equations (Equations (1.a) and (2)) are estimated by using a two-step generalized least squares (GLS) procedure. This method accounts for the autocorrelation of the residuals with a restricted parameter of autocorrelation. In this two-step procedure, we run the model by applying ordinary least squares. The residuals obtained from the first step are used to estimate the variances for each country to correct for heteroscedasticity.

Moreover, we also apply generalized method of moments (GMM) system estimations to account for endogeneity problems and for shock persistence. The GMM estimation method and results are discussed in Section 5.3. Robustness checks are shown in Section 5.4.

4. Data and Variables

Our data were obtained from different sources.[***] GDP, population, consumer price index (CPI) and official exchange rate data were obtained from the World Development Indicators (WDI) database. Our sample includes 22 developing countries over the period of 2003–2013. We selected these countries from the WDI's low-income group with a threshold level of foreign aid (ODA) to GDP ratio of 2%. We collected both the constant and the current GDP in the local currency and they have been calculated without making deductions for depreciation of fabricated assets, or for depletion and degradation of natural resources. The CPI data used 2010 as the base year. The ODA data were obtained from the Organization for Economic Co-operation and Development (OECD) database. The ODA inflow data were calculated by calendar year in US dollars. Countries such as Bulgaria, Latvia, Poland and Slovenia are not eligible for ODA funding; therefore, the ODA flows in these countries are referred to as Official Aid. We also collected the use of ODA disbursement from 2003 to 2013 in the five aforementioned sectors.[†††] For the source view of ODA, we obtained the top three donors' combined foreign aid versus the total ODA.[‡‡‡]

For the five sectors, we also calculated the use of ODA disbursement of to GDP ratio: the production sector to GDP ratio (PS) was calculated by dividing the total value allocated to the production sector divided by the GDP for each country and each year; similarly, the health and population sector to GDP ratio (HP) was calculated as the total value allocated to the health and population sector divided by the GDP; the education sector to GDP ratio (E) was calculated as the total value allocated to the education sector divided by the GDP; the humanitarian aid sector to GDP ratio (HA) is given by the total value allocated to the humanitarian aid sector divided by the GDP; and the economic infrastructure and services sector to GDP ratio (EIS) is computed as

[***] For the data construction process, see Appendix A.

[†††] The disbursement data for countries like Bulgaria, Latvia, Poland and Slovenia are unfortunately incomplete.

[‡‡‡] Foreign aid refers to ODA in our work.

the total value allocated to the economic infrastructure and services sector divided by the GDP. Lastly, in order to quantify the influence of the degree of diversification of the sources of foreign aid on risk sharing, we calculated the top three donors' added foreign aid to ODA ratio (TOP3) as the total value of foreign aid from the top three countries divided by the total ODA. We reported the average value of different sectors for from the ODA disbursement to GDP ratio between 2003 and 2013 (Figures 5–9). For the production sector, the ratio across sample countries varies from 0 to 0.30% (Vietnam) (Figure 5). For the health and population sector, the ratio varies from 0 to 0.80% (Botswana) (Figure 6); the last three sectors (education sector, humanitarian aid sector and economic infrastructure and services sector) vary from 0 to 0.55% (Cameroon) (Figure 7), 0 to 0.12% (Bosnia) (Figure 8), and 0 to 1.25% (Vietnam) (Figure 9) respectively.

5. Empirical Results

5.1 The extent of risk sharing via foreign aid

Table 1 reports the results obtained via Equation (1.a). We used the two-step FGLS estimation to capture the extent of risk sharing via foreign aid during the period 2003–2013 in 22 sample countries. According to Table 1, 1.36% of output shocks were smoothed through the foreign aid channel during this period. Further, since the amount of foreign aid distributed to developing countries is also heavily influenced by the donor countries' economy, in order to recognize the influence of the global financial crisis (GFC) on our test, we divided the sample time period into two sub-periods: 2003–2008 and 2009–2013 to capture changes between the periods before and after the inception of the GFC. During the period 2003–2008, 3.58% of output shocks were smoothed via foreign aid. This number is quite large compared to the overall extent of risk sharing via foreign aid (1.36%); for the period 2009–2013, it amounts to a statistically insignificant 0.18%.

These results are quite consistent with the analysis of Figures 3 and 4: the ODA to GDP ratios for our sample of countries have decreased greatly since 2008. More specifically, Figure 3 shows the average ODA to GDP ratio from 2003 to 2008, and

Figure 4 shows the average ODA to GDP ratio from 2009 to 2013. If we compare these two figures, we observe the differences in the average ODA to GDP ratio between these two sub-periods. For example, Bosnia decreased from 6.80% to 3.04%, Cameroon from 7.06% to 2.42%, Macedonia from 5.14% to 1.94% and Slovenia from 27.19% to 0.17%. Overall, the extent of risk sharing via foreign aid was greatly influenced by the GFC. Indeed, before the GFC, our results indicate that foreign aid acted as an effective channel insuring against domestic output shocks for developing countries.

5.2 Determinants of risk sharing via foreign aid

Table 3 reports the regression estimates for Equation (2). The purpose of these is to explore the determinants of risk sharing occurring through the foreign aid channel.

First, we quantified the impact of ODA disbursement on the extent of risk sharing via foreign aid. However, when countries face output shocks, they may allocate their received foreign aid to several different sectors to minimize the influence of shocks. By allocating more aid flows to a specific sector to dampen a specific negative influence of output shocks, countries may be able to buffer domestic output shocks more easily.

Our assumption is that different sectors have different abilities to smooth shocks. As a result, the extent of risk sharing may be different as a result of the different allocations of foreign aid to different sectors. In order to test our theoretical assumption, we collected the five main sectors for the ODA disbursement to GDP ratio. By testing each sector's disbursement to GDP ratio individually through Equation (2), we were able to recognize the ability of each sector to smooth shocks. As outlined before, the five sectors considered are: production; health and population; education; humanitarian aid; and economic infrastructure and services. In Table 2, we observe that ODA channelled to the production sector displays a positive ability to smooth shocks: the coefficient ß$_2$ is 10.45 and is highly significant (with a 2.68 *t*-statistic); however, in the multivariate case (Column 7) β_2 becomes statistically insignificant. This discrepancy between univariate and multivariate analyses is not

true for the other sectors. With regard to the education sector, its ability to smooth shock is also highly significant (the coefficient β_4 equals 14.20 with a 3.99 *t*-statistic), and the same is true for the economic infrastructure and services sector. Therefore, these three sectors all play a positive and significant role in risk sharing via foreign aid. However, for the other two sectors, our results indicate unsmoothing: for the health and population sector, the coefficient β_3 equals –4.13 (with a –2.82 *t*-statistic); for the humanitarian aid sector, the coefficient β_5 equals –35.33 (with a –2.00 *t*-statistic). These negative outcomes may occur due to the natural functions of each sector. For example, the humanitarian aid sector's purpose is to provide humanitarian aid in response to crises including natural disasters and man-made disasters. Thus the foreign aid allocated to this sector is the least likely to have an ability to share risk, as humanitarian aid does not fluctuate with the economic conditions. Due to the different abilities of the sectors of ODA disbursement in risk sharing, policy makers can target their foreign aid to the most appropriate sectors to suit their county's specific needs when facing output shocks. By doing this, the extent of risk sharing through foreign aid may increase.

Moreover, in Table 2, we can also observe a negative trend, which means that the extent of risk sharing via foreign aid across our sample countries has decreased over time. This finding is consistent with our results in Table 1, as the extent of the risk sharing via foreign aid decreased after 2009.

The second main hypothesis we tested is related to the degree of the diversification of the sources of foreign aid, which will determine the extent of risk sharing via foreign aid. The underlying concept is that if foreign aid is dependent on a limited number of countries, it is more likely that the donor countries will have synchronized business cycles and therefore, the risk sharing opportunities for the recipient countries of the foreign aid would be small. If the source of the foreign aid is diversified evenly, the extent of risk sharing via foreign aid might be larger. In order to quantify the degree of source diversification, we calculated the ratio of the top three donors' combined foreign aid to the total ODA ratio. The relationship between the diversification of the source of foreign aid and the top three donors' combined foreign

aid to total ODA ratio is negative and significant with a –0.12 coefficient. Accordingly, we are able to say that the smaller the contribution of the top three donors' foreign aid, the more the source of the foreign aid is diversified and thus the extent of risk sharing via foreign aid is greater. These results support our second assumption, indicating a strong and positive relationship between the degree of soruce diversification and the extent of the risk sharing via foreign aid.

5.3 GMM Estimations

When we estimate the main risk sharing equation via FGLS estimation, we implicitly assume that the shocks are short-lived. However, the output shocks can be persistent and we may need to take them into account in the estimated equations. A dynamic approach an account for long-lasting output shocks; accordingly, we applied a two-step GMM-sys in the estimations. The main equation is:

$$y_{it} = v_i + \alpha_1 y_{it-1} + \beta_0 \widetilde{GDP}_{it} + \beta_1 \widetilde{GDP}_{it-1} + \varepsilon_{it}.$$

(3)

The GMM-*sys* counterpart of Equation (2) is:

$$y_{it} = v_i + \alpha_1 y_{it-1} + \beta_0 \widetilde{GDP}_{it} + \beta_1 \widetilde{GDP}_{it-1} + \gamma \widetilde{GDP}_{it} * X_{it} + \delta \widetilde{GDP}_{it-1} * X_{it-1} + \varepsilon_{it},$$

(4)

where y_{it} represents $\widetilde{GDP}_{it} - (GDP_{flows})_{it}$, as defined previously in Equation (1.a), and X_{it} contains all the interaction variables (*PS*, *HP*, *E*, *HA*, *EIS* and *TOP3*). For the models with a low number of time observations, the fixed-effect models might not give unbiased estimations (Verbeek, 2008). Accordingly, one possible solution would be to use the GMM estimation introduced by Arellano and Bond (1991). This estimation method may be applied in two ways: either using differenced GMM

(GMM-*diff*) or system GMM (GMM-*sys*).[§§§] As shown by Arellano and Bover (1995), the difference GMM technique may have problems with weak instruments due to the presence of lagged level instruments. Instead, Blundell and Bond (1999) suggest that an application of the system GMM estimators is a more appropriate approach to dynamic panel data than using the GMM-*diff* estimators because of their greater efficiency. Owing to these issues, we have used GMM-*sys* estimators to estimate Equations (3) and (4); the GMM-*sys* involves two simultaneous equations for the levels of the equations. We have used the first differences as the instruments. For the first difference equations, we employ the lagged levels of the variables as instruments. The two equations – levels and differenced – are then combined to give the GMM system estimators. These instrumental variables are called internal instruments because they rely on previous realizations of the explanatory variables and we test their validity using the Sargan test and their consistency using the second-order serial correlation test.

Table 3 reports results for Equation (3), which is the GMM-*sys* counterpart of Equation (1). If we compare these results with those in Table 1, we get robust evidence of the positive and significant smoothing role of foreign aid in the pre-GFC period, which amounts to 6%, and thus is larger than that detected by applying GLS estimations. The results for the entire sample are consistent with those obtained via GLS estimations (slightly above 1%), while for the post-GFC periods, we get an insignificant coefficient when using GLS estimation and a dis-smoothing effect if we look at GMM-*sys* estimates.

Table 4 contains the estimates of Equation (4). The first-order and second-order AR correlation tests have *P*-values that are greater than 10%. These results indicate

[§§§] The differenced and system GMM estimators embody the following assumptions about the data-generating process: (a) the process may be dynamic, with current realizations of the dependent variable influenced by past realizations; (b) there may be arbitrarily distributed fixed individual effects; (c) some regressors may be endogenous; (d) the idiosyncratic disturbances (those apart from the fixed effects) may have individual-specific patterns of heteroskedasticity and serial correlation; (e) the idiosyncratic disturbances are uncorrelated across individuals; (f) the number of time periods of available data may be small; and (f) the only available instruments are "internal" – based on lags of the instrumental variables (Roodman, 2009).

that there is not enough evidence of correlation and the use of lags of the dependent variable would be valid as instruments. Moreover, the Sargan test (the row at the end of the table) indicates that the instruments we are using are exogenous. The estimations show a significant lagged effect of the dependent variable on the risk sharing regressions, indicating a persistency effect of the shocks on risk sharing regressions. This is important because the previous model was not able to measure the persistency effect. Indeed, the coefficient estimates we obtain applying GMM-*sys* are systematically different from those reported in Table 2. Compared to the GLS estimations, only the univariate regression results show some significant estimates with the trend variable. However, consistent with the results in Table 2, humanitarian aid is negative and significant, signalling how humanitarian aid may be effective for short-term income smoothing, but for the long-term it may play no role. However, this variable also turns out to be significant in the last column when we add all the variables together. On the other hand, the proportion of foreign aid originating from the top three donor countries has negative and significant coefficients in both the univariate and multivariate analyses (Columns 4 and 6). This finding is also consistent with the results in Table 2, which predict a negative impact on risk sharing if the foreign aid flows from only a few countries.

5.4 Robustness checking

If a country's income process changes as they receive more aid from foreign donors, then the estimated coefficients in Tables 2 and 4 might be biased in measuring the extent of the risk sharing via foreign aid. In particular, the variables we proposed can be the main determinants of the volatility of GDP. For instance, if any independent variable is significantly increasing or decreasing the volatility of the GDP, then risk sharing estimates will be biased towards that variable, since it has already boosted or dropped the volatility of the GDP. Accordingly, we test if our independent variables have any impact on the volatility of GDP by running the following regression:

$$\widetilde{GDP}_{it} = c + \beta_1 PS_t^i + \beta_2 HP_t^i + \beta_3 E_t^i + \beta_4 HA_t^i + \beta_5 EIS_t^i + \beta_6 TOP3_t^i + \varepsilon_{it}, \quad (5)$$

where $\widetilde{GDP}_{it}$ is the rate of growth of idiosyncratic income de-meaned by the group average, which represents the idiosyncratic volatility of domestic output in country *i* in year *t*. $\hat{\beta}_i$ (for i=1,2,…6) quantifies the relationship between $\widetilde{GDP}_{it}$ and other potential explanatory variables. The explanatory variables *PS*, *HP*, *E*, *HA*, *EIS* and *TOP3* in Equation (5) have the same definitions as described in Section 4.

Table 5 reports the estimation results. According to Table 5, most of the estimated coefficients are insignificant. The only exception is the health and population sector, for which the coefficient β_2 is at –1.67 (with a –3.50 *t*-statistics). More importantly, the R^2 values of both the multivariate and univariate analyses are very small, so we are able to conclude that none of the factors we presented in Tables 4 and 5 is strong enough to explain the volatility of the GDP. Accordingly, we are able to use these variables, knowing that they do not have a significant impact on the volatility of domestic output.

6. Conclusions

We explored the potential of foreign aid as an effective channel of international risk sharing in developing countries. From a sample of 22 developing countries over the period 2003–2013, our results suggest that foreign aid inflows play an important role in providing insurance against domestic output shocks in developing countries. On average, 1.36% of shocks were smoothed across the sample period (1.08% if we look at GMM-*sys* estimates). When we removed the influence of the GFC in 2008, the amount of shocks smoothed via foreign aid increased to 3.58% or to an even higher 6% in the case of GMM-*sys*.

The present study makes two main contributions employing both the FGLS and GMM techniques. First, it confirms the effectiveness of foreign aid as a channel for international risk sharing among developing countries, and it fills the gap between the literature on the effectiveness of foreign aid and studies of international risk sharing.

Second, it investigates the determinants of risk sharing via foreign aid revealing as the humanitarian aid sectors can be effective only for short term income smoothing, while for the long run it may play no role. Moreover, robust empirical evidence indicates that a high degree of diversification of the sources of foreign aid can contribute greatly to risk sharing via foreign aid. These results could provide new guidance for studies on the effectiveness of foreign aid as well as for policy design.

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Appendix A. Data description and sources. Variables used to obtain the estimate of risk sharing via foreign aid inflows

Official development assistance	In million US$ from the Organization for Economic Co-operation and Development (OECD) database
GDP (Constant in LCU)	The gross domestic product constant in the local currency. Source: the World Development Indicators (WDI) database
GDP (Current in LCU)	Source: the WDI database
Consumer price index (CPI)	Using 2010 as the base period from the WDI's database
Population	Source: the WDI database
Official exchange rate	Source: the WDI database
Explanatory variables	
GDP per capita	The GDP divided by the midyear population. For different years, we readjusted the amount of GDP per capita by dividing by each year's CPI to deduct the influence of inflation.
GDP_{flows}	The log difference of (*GDP+ODA*) per capita between year t_{i-1} and t_i. It is calculated as: log (*GDP+ODA* per capita at t_i)-log (*GDP+ODA* per capita t_{i-1}). The amount of GDP per capita was calculated by dividing by each year's CPI to deduct the influence of inflation.
Production sectors to GDP ratio	The amount of ODA disbursements used by production sectors, divided by GDP. Source: the OECD database.
Health and population sector to GDP ratio	The amount of ODA disbursements used by the health and population sector, divided by GDP. Source: the OECD database.
Education sector to GDP ratio	The amount of ODA disbursements used by the education sector, divided by GDP. Source: the OECD database.

Humanitarian aid sector to GDP ratio	The amount of ODA disbursements used by the humanitarian aid sector divided by GDP. Source: the OECD database.
Economic infrastructure and services to GDP ratio	The amount of ODA disbursements used by the economic infrastructure and services sector divided by GDP. Source: the OECD database.
Top 3 donors combined foreign aid to ODA ratio	The combined value of the top 3 donor countries' ODA divided by total ODA. Source: the OECD database.
List of countries	
Sample countries (22)	Azerbaijan (AZE), Bosnia and Herzegovina (BIH), Botswana (BWA), Brazil (BLZ), Bulgaria (BGR), Cameroon (CMR), Chile (CHL), Colombia (COL), Egypt (EGY), Indonesia (IDN), Kazakhstan (KAZ), Latvia (LVA), Macedonia (MKD), Nigeria (NGA), Peru (PER), the Philippines (PHL), Poland (POL), Slovenia (SVN), Thailand (THA), Turkey (TUR), Venezuela (VEN), Vietnam (VNM)

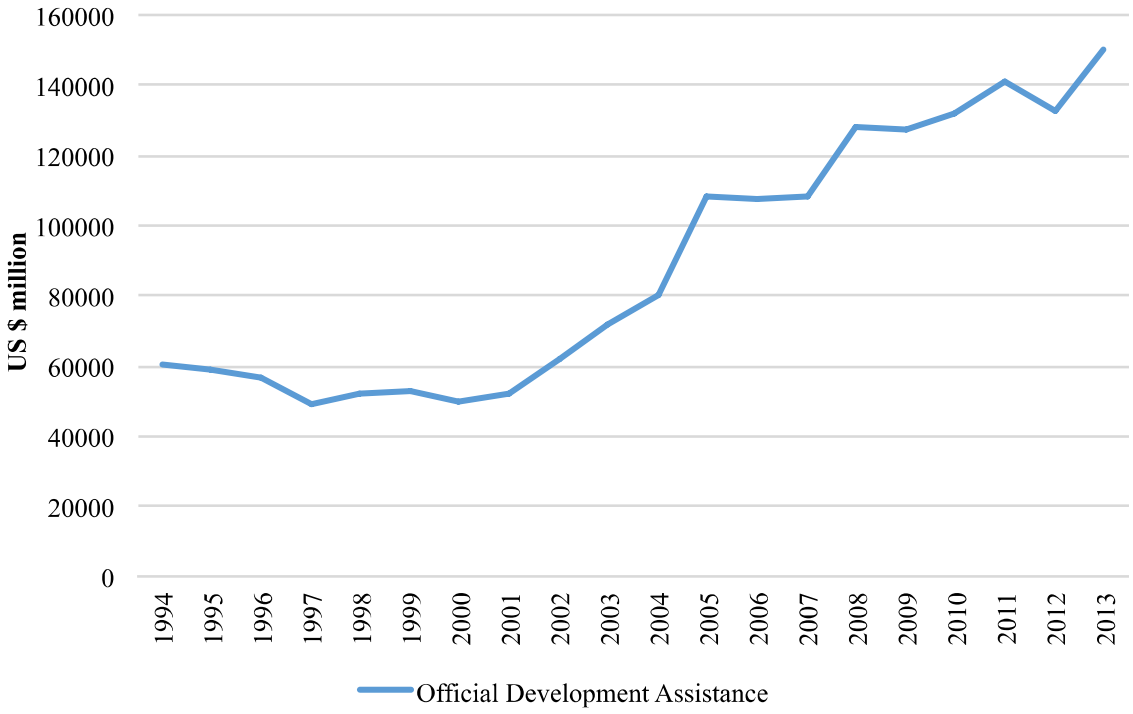

Figure 1: Amount of official development assistance allocated to developing countries during 1994 to 2013.

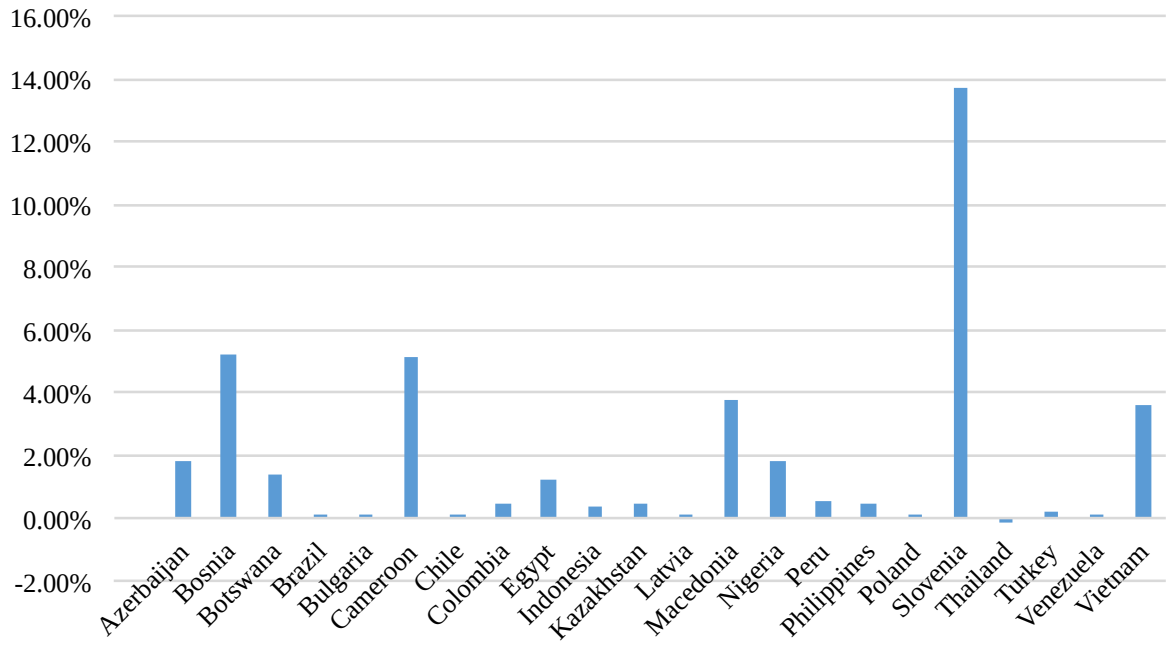

Figure 2: The average official development assistance to gross domestic product ratio from 2003 to 2013 in the sample countries.

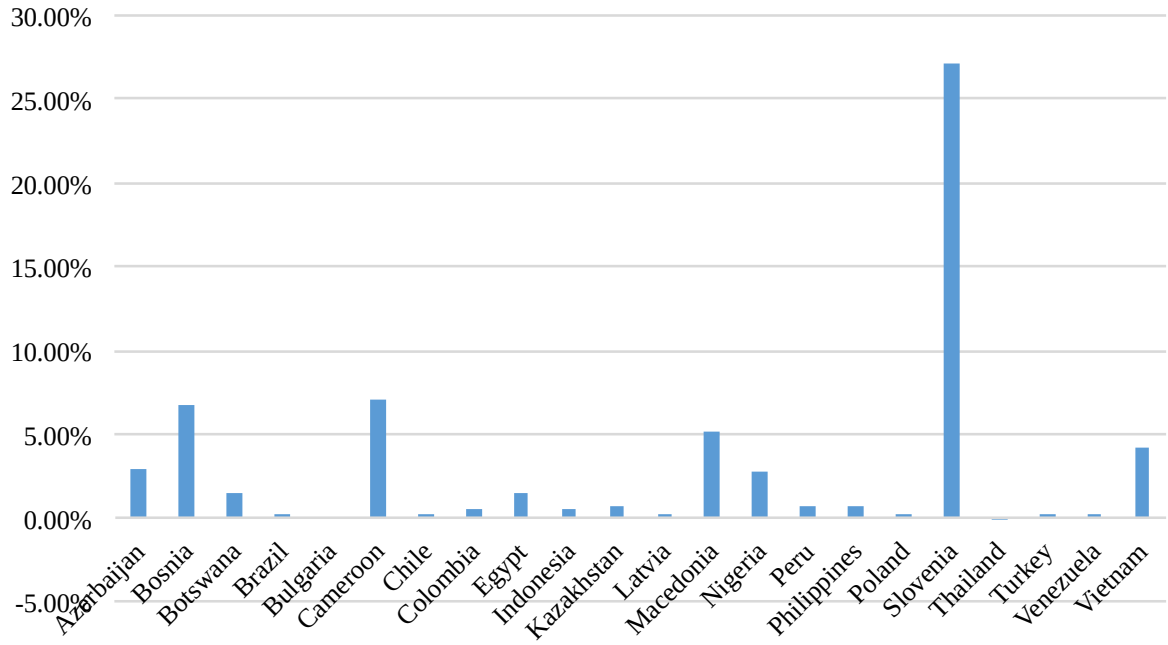

Figure 3: The average official development assistance to gross domestic product ratio from 2003 to 2008 in the sample countries.

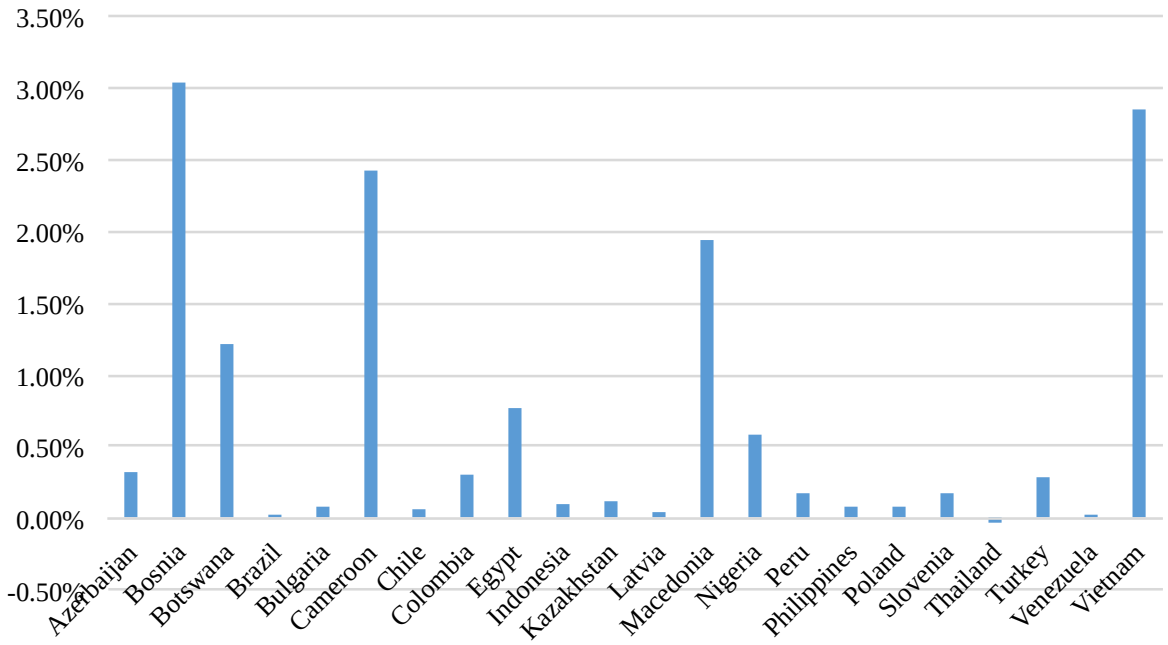

Figure 4: The average official development assistance to gross domestic product ratio from 2009 to 2013 in the sample countries.

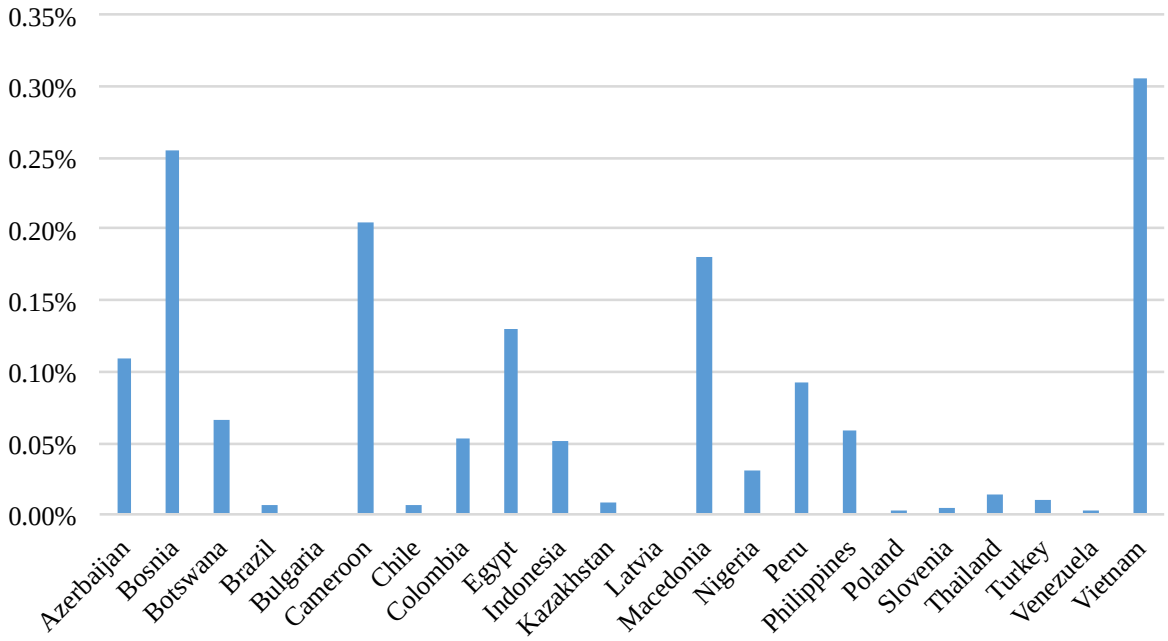

Figure 5: The average share of the production sectors in the official development assistance disbursement to gross domestic product ratio from 2003 to 2013.

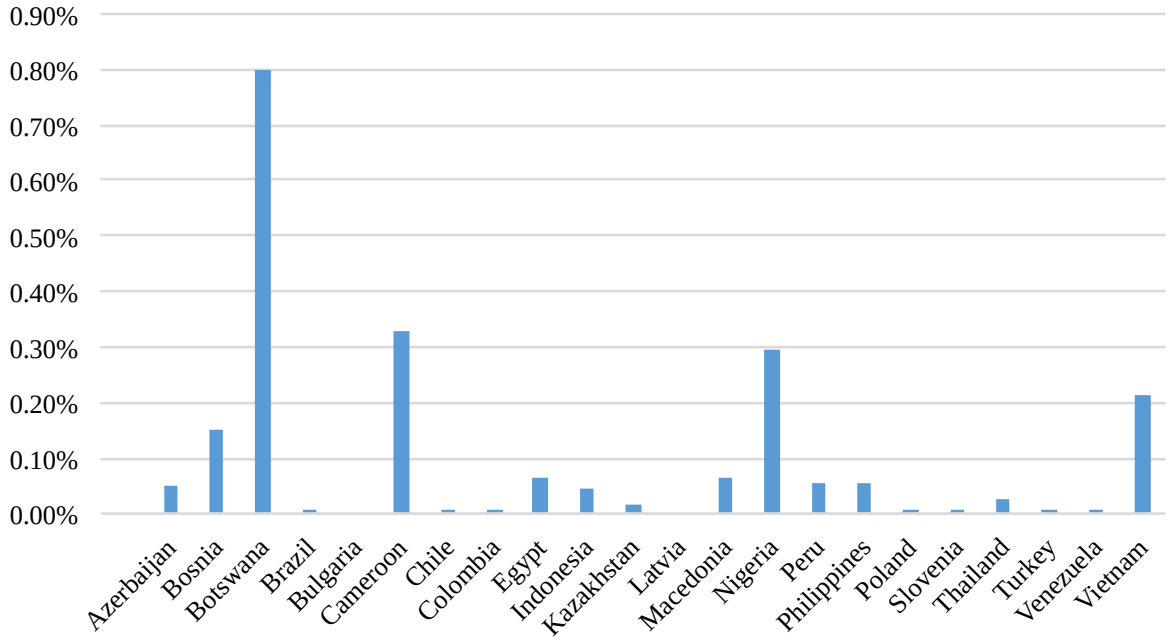

Figure 6: The average share of the health and population sector in the official development assistance disbursement to gross domestic product ratio from 2003 to 2013.

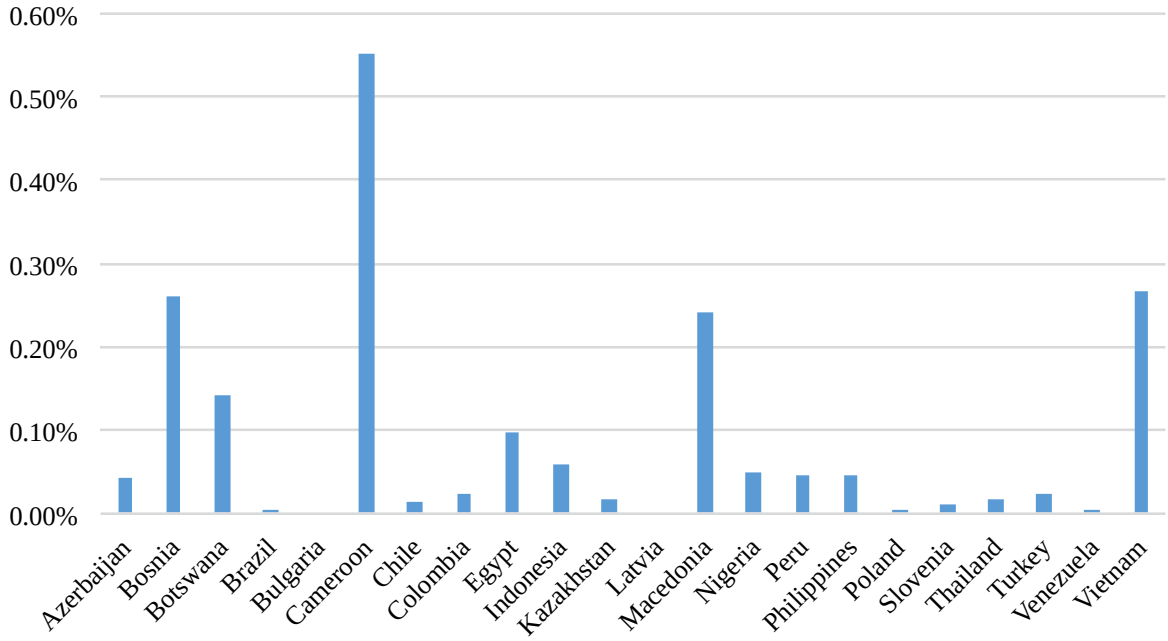

Figure 7: The average share of the education sector in the official development assistance disbursement to gross domestic product ratio from 2003 to 2013.

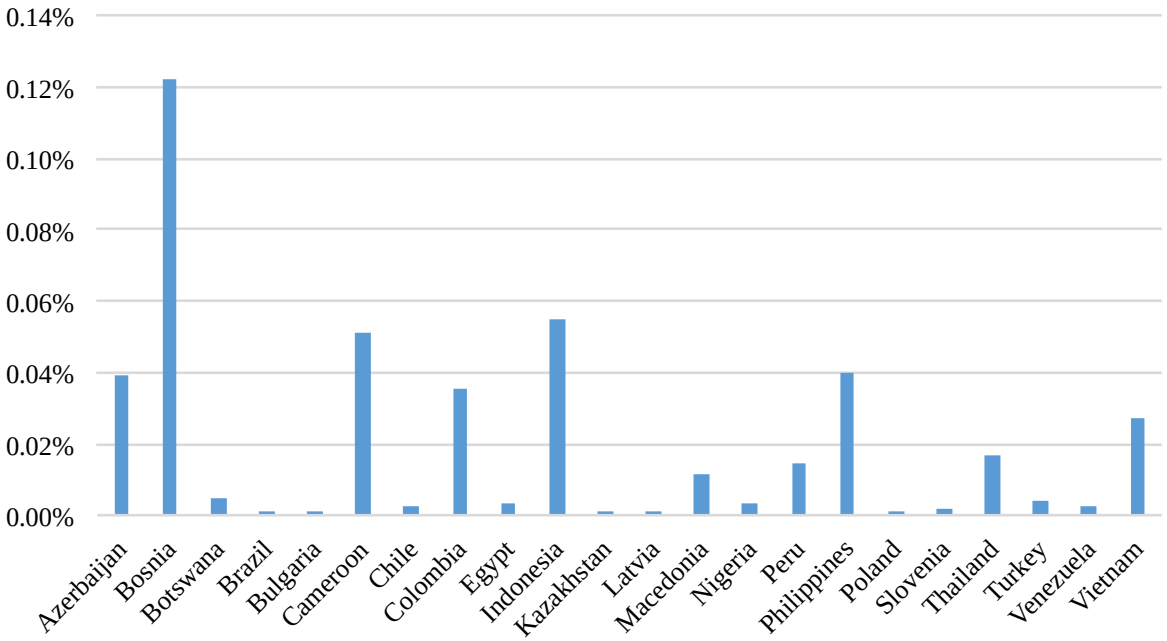

Figure 8: The average share of the humanitarian aid sector in the official development assistance disbursement to gross domestic product ratio from 2003 to 2013.

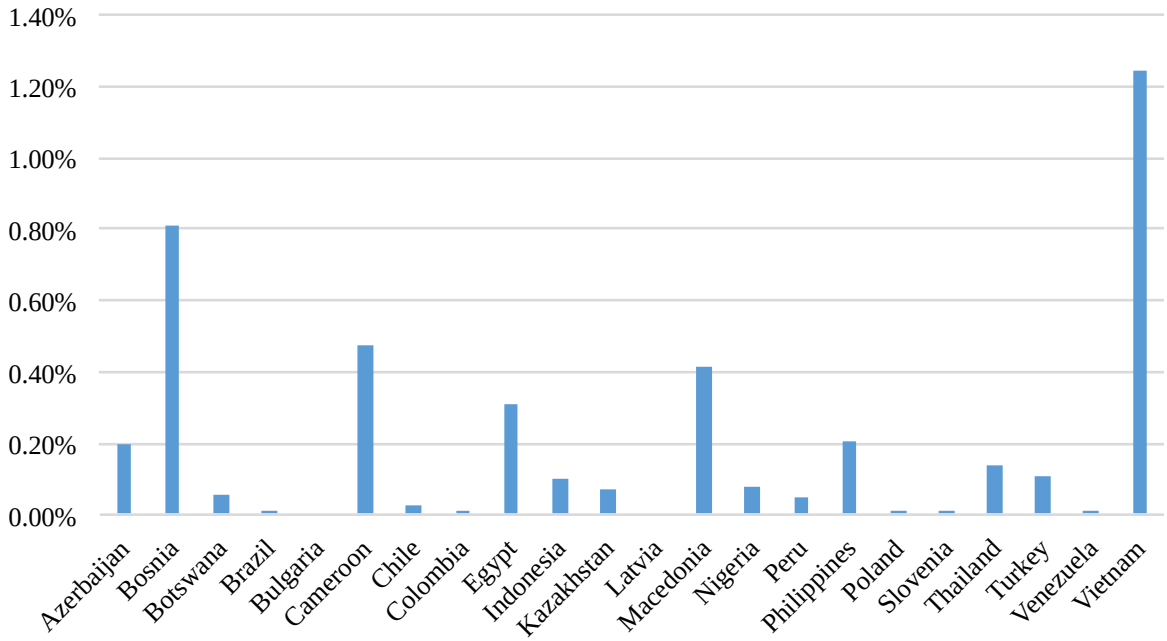

Figure 9: The average share of the economic infrastructure and services sector in the official development assistance disbursement to gross domestic product ratio from 2003 to 2013.

Table 1. Risk sharing via foreign aid (FGLS estimations)			
	2003–2008	**2009–2013**	**2003–2013**
$\hat{\beta}_0$	3.58%	0.18%	1.36%
	(3.92)***	(0.61)	(3.99)***
R^2	0.14	0.08	0.11
Observations	104	107	211

Note: This table reports the panel estimation results obtained from Equation (1.a). *T*-statistics are given in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. FGLS stands for the Estimated Generalized Least Squares estimation method. The estimation method is explained in detail within the text.

Table 2. Leading determinants of risk sharing via foreign aid (FGLS regressions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\hat{\beta}_0$	0.02	0.06	0.03	0.05	0.04	0.13	0.09
	(2.30)**	(5.34)***	(3.52)***	(2.96)***	(3.50)***	(4.99)***	(3.01)***
Trend	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(-2.46)**	(-4.08)***	(-3.70)***	(-2.76)***	(-3.60)***	(-2.81)***	(-3.12)***
Production Sectors	10.45						6.06
	(2.68)***						(1.04)
Health and population		-4.13					-3.45
		(-2.82)***					(-1.54)
Education			14.20				10.33
			(3.99)***				(2.14)**
Humanitarian aid				-35.33			-25.55
				(-2.00)**			(-2.03)**
Economic infrastructure and services					4.61		3.55
					(2.52)**		(0.67)
Top 3 donor combined ratio						-0.12	-0.19
						(-3.37)***	(-3.75)***
R^2	0.34	0.15	0.34	0.25	0.26	0.31	0.59
Observations	172	172	172	184	172	171	171

Note: This table reports the panel estimations results obtained from Equation (2). The explanation of the estimation procedure is provided in the notes of Table 1; *t*-statistics are given in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 3. Risk sharing via foreign aid (GMM-*sys* estimations)

	2003–2008	**2009–2013**	**2003–2013**
Y_{t-1}	-0.17	0.14	0.24
	(3.12)***	(2.17)*	(2.26)**
$\hat{\beta}_0$	6.00%	-2.05%	1.08%
	(2.58)***	(3.14)***	(2.51)***
Sargan test	0.15	0.19	0.72
AR(1)	0.99	0.89	0.64
AR(2)	0.98	0.67	0.78
Observations	77	78	164

This table reports the panel estimations results obtained from Equation (3). *T*-statistics are reported in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The GMM-system estimation method is used for the estimation. The estimation methodology is explained in Section 5.3.

Table 4. Leading determinants of risk sharing via foreign aid: GMM-*sys* regressions

	(1)	(2)	(3)	(4)	(5)	(6)
Y_{t-1}	-0.17	-0.13	-0.17	-0.39	-0.19	-0.58
	(31.08)***	(20.12)***	(-25.83)***	(-17.83)***	(-19.75)***	(-3.01)***
$\hat{\beta}_0$	-0.02	0.07	-0.13	0.14	-0.13	0.03
	(-1.33)	(6.77)***	(-7.16)***	(4.07)***	(-4.29)***	(1.12)
Trend (T)	0.01	-0.001	0.02	-0.001	0.01	0.05
	(1.22)	(7.76)***	(6.99)***	(1.67)*	(3.76)***	(0.74)
Production Sectors	9.45					-38.89
	(1.05)					(0.11)
Humanitarian Aid		-16.99				0.38
		(-3.24)***				(0.79)
Economic infrastructure and services			0.53			1.21
			(0.28)			(1.55)
Top 3 donor added ratio				-0.23		-1.27
				(-6.05)***		(2.34)**
Health and population					-0.45	-0.66
					(-1.29)	(-0.23)
AR(1)	0.14	0.03	0.04	0.12	0.15	0.12
AR(2)	0.65	0.68	0.67	0.61	0.571	0.77
Sargan test	0.41	0.75	0.41	0.63	0.61	0.99
Observations	133	133	133	133	133	133

This table reports the panel estimations results obtained from regression Equation (4) as explained in Section 5.3; *t*-statistics are given in parentheses. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. For a detailed description of the explanatory variables, see Appendix A.

Table 5. Robustness checking

Dependent variable: $\widehat{GDP}_{it}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Production sectors	2.47 (0.84)						11.34 (1.98)**
Health and population		-1.67 (-3.50)***					-2.25 (-3.19)***
Education			-2.04 (-1.58)				-0.43 (-0.11)
Humanitarian aid				10.11 (1.17)			8.79 (1.64)
Economic infrastructure and services					-0.33 (-0.48)		-1.85 (-2.73)***
Top 3 donor combined ratio						0.02 (0.84)	0.04 (2.26)**
R^2	0.01	0.02	0.01	0.01	0.00	0.00	0.08
Observations	172	172	172	186	172	171	157

The estimation procedure is reported in Section 5.4. The dependent variable is $\widehat{GDP}_{it}$ $\widehat{GDP}_{it}$ is the rate of growth of idiosyncratic income de-meaned by the group average. T-statistics are given in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.